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Interactive mapping for the documentation of cultural heritage in Siwa Oasis, Egypt

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ABSTRACT

Mapping and documenting cultural heritage (CH) are essential for preserving and managing it. Heritage sites risk losing their identity and falling into danger without accurate documentation, and it is challenging to manage preservation plans for future generations. Egypt boasts a rich and diverse cultural heritage, encompassing both tangible and intangible aspects. Lack of documentation is one of the major problems faced by preservation efforts in Egypt. This research focused on the Siwa Oasis in the western desert, which has a rich cultural, natural, and historical heritage and requires comprehensive documentation of its landmarks, natural attractions, and handicrafts. This paper presents a methodology for documenting and mapping tangible and intangible cultural heritage in Siwa Oasis. It presents questionnaires to evaluate the status of handicrafts by conducting a SWOT analysis of the sector. The spatial, descriptive, and photographic data are collected through site visits and from published scientific resources and integrated into the GIS database. ArcGIS is used to incorporate different types of data and create maps. Finally, interactive maps and Story Maps present descriptive maps and photographs to the public, experts, and decision-makers.

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1. Introduction

Cultural Heritage (CH) is a universal value for all humanity. It forms part of human identity and history and must be preserved for future generations. It stems from humanity's ancient innovations (Alsamara et al., 2022). It can be tangible, such as buildings, museums, collections of objects, books, and works of art, or intangible (e.g. folklore, traditions, language, and knowledge and skills) (Abdelalim & Fahmy, 2017). Both are vital economic engines and part of national identity. Both natural and man-made forces threaten CH. UNESCO's 2003 Convention for the Safeguarding of the Intangible Cultural Heritage (ICH) encouraged safeguarding efforts (Yousef et al., 2022).

Documenting all CH elements is therefore significant for understanding their value and preserving them (Horbiński & Smaczyński, 2023). This complex task requires a comprehensive approach. Tangible cultural heritage (TCH) faces threats from natural hazards, climate change, and conflict (Van Balen, 2017) While ICH risks are vanishing due to competition from manufactured products and a breakdown in inter-generational knowledge transfer (Co-Curriculum Centre (Cluster for Arts and Cultural Heritage), Centre for

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Fundamental and Liberal Education, University Malaysia Terengganu (UMT), 21030 Kuala Nerus, Terengganu, Malaysia et al., 2020). Advanced digital technology is a key tool for sustaining ICH (M. Z. Idris et al., 2016), enabling institutions and communities to document, archive, and share heritage.

Geographic Information Systems (GIS) powerfully integrate spatial and descriptive data. While widely used to document TCH sites globally – such as documenting archaeological sites in Qatar (Cuttler et al., 2013; Halabi et al., 2022), Saudi Arabia (AlIheeib et al., 2022), Italy (Lezzerini et al., 2016), and Turkey (Toz & Duran, 2004), a key example being the mapping of handicraft centers in New Valley, Egypt (Yousef et al., 2022).

The growing importance of innovative documentation approaches reflects the need to address heritage sites facing social and urban changes, as well as to preserve the identity of the CH site that could be threatened (Gaspari et al., 2024). Interactive technologies, particularly interactive maps, have demonstrated a significant impact by combining web mapping with multimedia content to create accessible platforms that integrate fragmented data sources (Maiellaro, 2015; Marian et al., 2022). These tools also facilitate community involvement in preservation efforts, as evidenced by Albania's SCHEME project, where interactive maps supported community engagement and crowdfunding initiatives for site rehabilitation (Dollani et al., 2016).

Interactive maps, Story Maps, and other digital tools are also significant in sustainable CH management. For example, the GREEK-NEW LIFE project utilized interactive platforms to maintain engagement with cultural content over time, ensuring that CH remains relevant and accessible (Podara et al., 2021). Such innovations combine interactive platforms, crowdsourcing, and advanced imaging techniques to promote and sustain CH. They tackle environmental and social challenges, thus making CH more accessible and attractive to future generations while preserving it for years to come. The Chan Chan in Peru project, the largest adobe city in the world and a UNESCO World Heritage Site, integrates field surveys for data collection, GIS for database management, and GIS-based storytelling (specifically using ArcGIS StoryMap) for interactive dissemination (Malinverni et al., 2019).

Interactive mapping, while enhancing accessibility, has limitations that researchers and practitioners must address. Digital platforms, such as GIS and Story Maps, cannot fully capture sensory experiences (e.g. textures, sounds of handicraft workshops or springs), thereby risking an incomplete representation of intangible heritage (M. Z. Idris et al., 2016; Olaz et al., 2022). Technical barriers – such as dependency on the internet/power in remote areas, high software/maintenance costs, and required expertise – limit access for non-technical users or communities in developing regions (Dollani et al., 2016; Kolivand et al., 2018). Data quality issues, such as spatial inaccuracies or obsolescence due to environmental changes (e.g. salinization), undermine risk assessments, as GIS vector manipulation may overlook dynamic threats (Hamrouni & Amer, 2021; Kolivand et al., 2018). Privacy concerns and the over-reliance on technology versus on-the-ground expertise further restrict applications (Olaz et al., 2022). To address these, practitioners should combine digital tools with fieldwork, integrate multilingual and community-driven features, and ensure regular updates, as suggested in GIS-based heritage studies (Gaspari et al., 2024; Horbiński & Smaczyński, 2023).

Egypt, with a civilization spanning six millennia, has a rich legacy of monuments and cultural properties (Zakaria, 2019). The Siwa Oasis in the Western Desert is a prime example, known for its historical sites, unique language, and traditional craftsmanship. (Ahmed, 2023; Souryai, 2001). Regarding Siwa Oasis, its historical sites, unique language, traditional craftsmanship, and natural beauty have a significant impact on its culture. Efforts to preserve and promote Siwa's heritage are crucial to maintaining its historical significance and ensuring that its cultural practices are sustained amid modern challenges. Therefore, this paper provides a comprehensive methodology for documenting and mapping ICH, TCH, and handicrafts in Siwa Oasis. The data are collected through site visits and from published scientific resources and then integrated into the GIS database. The study used a questionnaire and meetings with craftsmen and experts to conduct a SWOT analysis of the current situation of the handicraft centers. ArcGIS integrates the different data types into a GIS database and then creates maps for various kinds of CH in Siwa Oasis. Finally, the outputs are presented through interactive maps and Story Maps, offering access for both the public and specialists.

This paper contributes a widely manageable, GIS-based interactive mapping and StoryMap platform that integrates spatial, descriptive, and photographic documentation of Siwa's tangible and intangible heritage, providing the first comprehensive digital repository for the oasis while enabling ongoing community-driven updates and sustainable tourism planning.

2. Materials and method

2.1. Study area-site characteristics

Siwa Oasis is rich in cultural and historical heritage, located in northwestern Egypt. It is part of Marsa Matruh Governorate (Faragallah, n.d). And approximately 260 kilometers south of Matrouh City. As shown in Figure 1, this region is located between latitudes $29^{\circ} 60' 7.91''$ N and $29^{\circ} 19' 28.609''$ N, and longitudes $25^{\circ} 16' 40.761''$ E and $25^{\circ} 49' 5.243''$ E. Geographically, Siwa Oasis is a lush oasis surrounded by barren peaks. The Depression has an uneven, elongated form that stretches in an E-W direction, with a maximum length and breadth of approximately 80 and 27 km, respectively. The entire area of the Oasis is approximately 1018 km², and the highest depth is roughly 18 m below mean sea level (Elsheikh et al.,

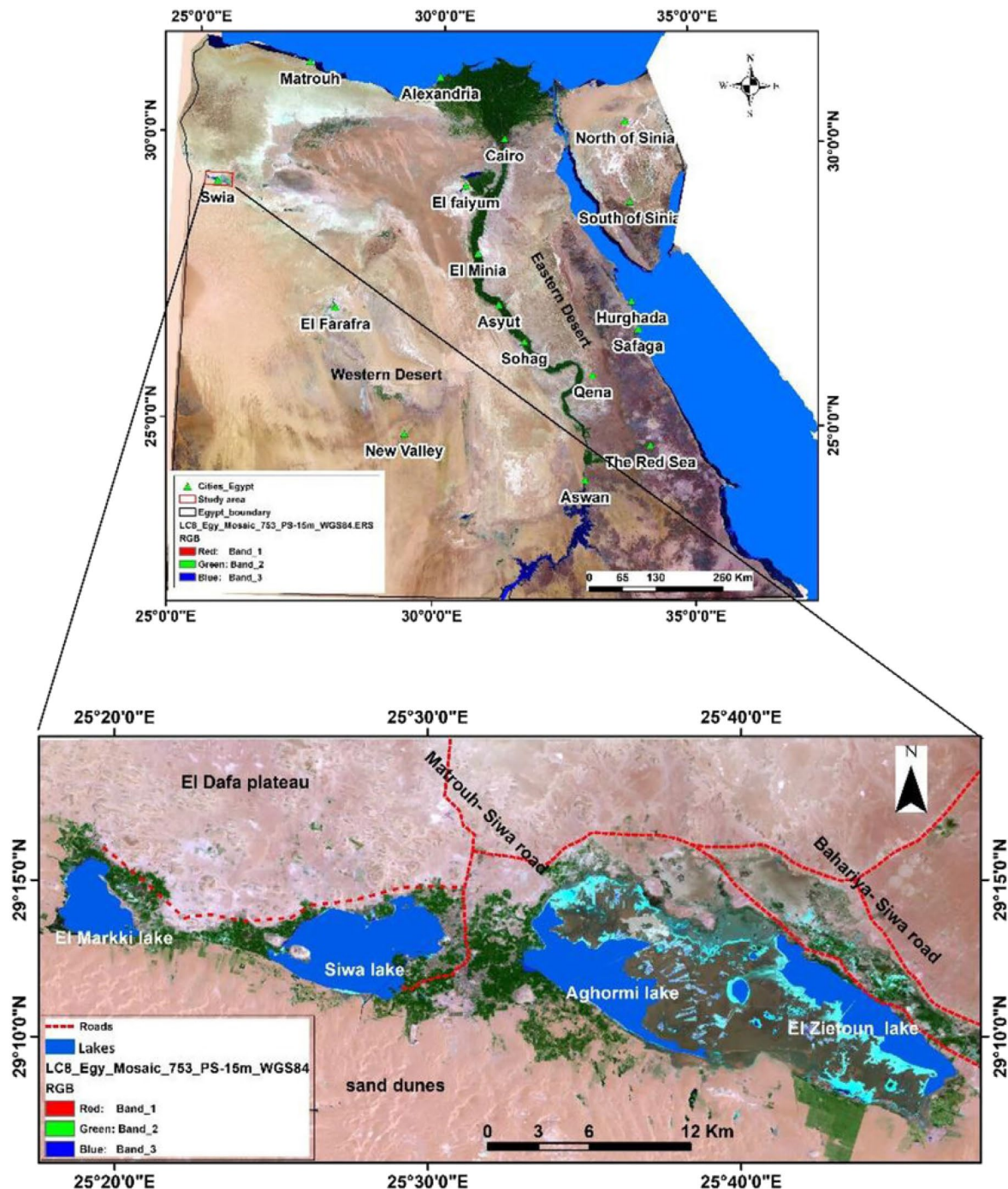


Figure 1. Siwa Oasis location (Elsheikh et al., 2023).

2023). The surface composition of the Siwa Oasis is quite complex, with differences in geomorphology, geology, seismology, and soil phenomena (Saleh, 2017).

The Siwa Oasis is divided into two parts by El-Salehia, part of the Saad El-Din Mountains. The southern part of the Oasis consists of sandy dunes and palm trees with salty water. These trees are irrigated from the Great Sea, known as Ain Hammam, where small salt lakes are found to extract salt and sand. More fresh water can be found in El-Shalout, Zigaga, and nearby Ghudwan. In the northern part of the Siwa Oasis, fresh water is available at Fatnas Lake, which features 1,000 palm trees. Additionally, fresh water is available in El-Maefam, near Birket Al-Tavilah. Fresh water can be found in the Los Mountains, where the forests of the Jebel El-Mawta graves are located (Faragallah, n.d).

The Egyptian Antiquities Organization listed the Siwa Ancient Area on the tentative list for UNESCO World Heritage in 1994. It contains nine ancient monuments, all of which are under the control of the Ministry of Antiquities and Tourism. The region comprises urban space and a buffer zone, including Siwa Lake, Siwa Oasis, and the Great Sand Sea. The government's historic management strategy is centralized, with little local community involvement. In 2015, Ccumene Studio collaborated with community leaders to create SIWI. This participatory effort combines bottom-up and top-down decision-making to increase awareness about Siwan's architectural legacy and define a new urban vision (Hamrouni & Amer, 2021).

2.2. Study aim and objectives

The study aims to achieve the objectives below by promoting the cultural and historical significance of Siwa Oasis, with a focus on its handicrafts, archaeology, tourist attractions, lakes, and historical springs.

- Collect spatial, descriptive, and photographic documentation of ICH&TCH in Siwa Oasis.
- Implement the collected documentation in (GIS) to map the different types of CH in Siwa Oasis.
- Use interactive mapping and story Map to present CH data to the public, experts, and decision-makers.

2.3. Study methodology

The research methodology for documenting ICH and TCH of Siwa Oasis consisted of three steps. (Malinverni et al., 2019) A field visit, which included data collection, creation of a GIS database, and design of an Interactive map and Story Map, as shown in Figure 2.

2.3.1. Field visit

The research team conducted the field visit in two different periods, each lasting ten continuous days. During the two trips, the following activities were done:

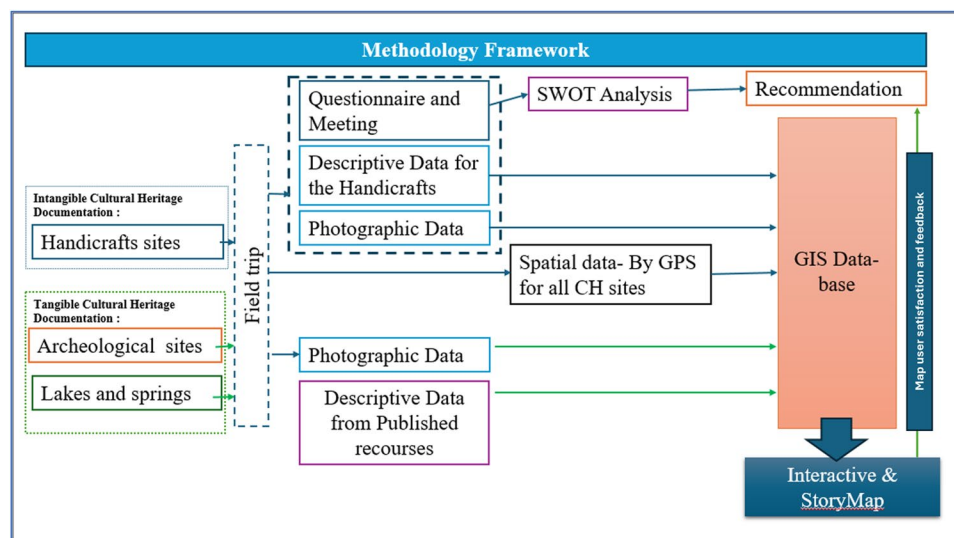


Figure 2. The methodology framework.

2.3.1.1. Data collection.

a. Descriptive documentation

- The descriptive data for archaeology, tourism, lakes, and springs sites were collected from published scientific resources. However, the available data on handicraft centers in published resources was insufficient; therefore, additional data was collected during the visit through meetings with government departments, civil society organizations, and individuals working with handicrafts in the city.
- The research team distributed a questionnaire to different groups of handicraft practitioners and experts to collect information about the handicrafts' current status, needs, and suggestions.
- Ethical Approval and Informed Consent

No independent university IRB/Ethics Committee was available in the study setting; therefore, ethical oversight for this study was provided by the Ministry of Tourism and Antiquities (MoTA), Egypt, the competent authority for cultural heritage field research in Egypt. Approval was granted by letter from MoTA without a numerical ethics ID. Informed consent for participation was obtained orally from all participants before their inclusion in the study. We adopted oral (rather than written) consent because the activities were minimal risk, collected no direct personal identifiers, and were conducted in remote outdoor field conditions (>40°C, dust/sand, no desks/printers), where requesting signatures is often impractical and culturally sensitive. Consent was documented in a researcher-signed Consent Log (participant code, location, date/time, activity). Where permitted, we recorded a brief audio confirmation linked to the participant code; when audio was not appropriate, a field witness co-signed the log. No names or contact details were collected.

b. Spatial documentation

Spatial data for TCH and ICH were collected in situ with a Magellan GPS 300 (a self-contained handheld GPS receiver designed for positioning and navigation). From the start, the devices achieve a first position fix within 2–3 min after receiving signals from more than three satellites. Coordinates were recorded in latitude/longitude (WGS84) on the device and later projected in GIS to the appropriate UTM zone for analysis and mapping. The GPS device stores points as 'landmarks' (i.e. waypoints), which were used for documenting the sites.

2.3.1.2. Field protocol.

1. Pre-field setup. Configure the GPS to the WGS84 datum and enable the DMS (Degrees, Minutes, Seconds) display. Set the local time, clear old landmarks/tracks, and prepare a waypoint naming scheme (e.g. CH001 for cultural heritage, HC001 for handicraft). Print a one-page data dictionary listing required attributes (site type, name, condition, date/time, collector, notes, photo ID).
2. Signal acquisition and quality check. For each site location, move to an open-sky position near the feature's representative point (e.g. entrance/centroid). Power on, wait for satellite lock, and verify a stable fix (the satellite count remains stable for at least 15–30s). When possible, accept points only when the on-screen estimated error is small and the geometry is stable (i.e. low dilution of precision).
3. Position capture (and quick averaging). Hold the receiver still over the point for 30–60s and record 3–5 successive readings (5–10s apart). Save the reading with the smallest estimated error as the primary landmark and jot the others in the field sheet for manual averaging if needed. (This emulates 'position averaging' on devices that lack an averaging function.)
4. Waypoint creation and attributes. Save the position as a landmark on the device (accept or edit the auto-generated name) and record the matching Waypoint-ID on the field form with site name, type (archaeological/handicraft), brief description, photo IDs, and any access/visibility notes. Capture at least one geotagged photo, or, if not available, a photo referenced by Waypoint ID.
5. Daily QA/QC and backups. At the end of each day, review landmarks on the receiver, delete duplicates, and export data via cable/NMEA to CSV/GPX. Back up raw files immediately (YYYYMMDD naming). Maintain a simple log sheet (including start/stop times, team, weather, and any issues).

6. Post-field processing. Import waypoints to GIS, define WGS84, and project to the study area's UTM zone. Join the attribute table from field sheets by Waypoint-ID; inspect against basemaps/satellite imagery to flag outliers.

The field team faced multiple challenges due to the study area's remote desert location, which degraded data quality and slowed down the acquisition process. Extreme heat, intense solar radiation, dust, and intermittent sandstorms affected screen legibility, operator endurance, and device reliability, with a risk of device shutdown due to overheating. Loose sandy terrain and shifting dunes limited vehicle access and made it difficult to occupy stable, representative points around oases and Lakes. Operationally, Siwa's isolation (more than 500km from Cairo) created logistical delays, while weak or absent cellular service prevented on-site verification and syncing of the basemap.

a. Photographic documentation

During the field visit, the various heritage areas in Siwa Oasis were photographically documented using Canon DSLR digital cameras, which produce high-quality photos and ultra-clear 18-megapixel images for designing the interactive map.

b. SWOT analysis

The evaluation of handicrafts in the Oasis was conducted through a four-part analysis (SWOT Analysis), which includes an assessment of strengths, weaknesses, opportunities, and threats.

2.3.2. GIS database

The spatial data from the GPS 300 Magellan and descriptive data collected from interviews, questionnaires, and published scientific sources were used to create a GIS database for TCH and ICH sites in Siwa Oasis. ArcGIS was used to convert GPS-collected data into point thematic layers, and descriptive data was added as attribute information to these layers. The GIS data, combined with the base map, was used to prepare maps of heritage sites for presentation on the Interactive map.

2.3.3. Design of interactive map and story map

The interactive map was designed to create an online platform that visualizes various data (descriptive information, photographs, digital maps) for the CH sites in an interactive manner for experts, decision-makers, and users interested in the CH sites. The data was uploaded to an ArcGIS Online Server. Hosting this data on an integrated digital platform (Data Hub) allows users to easily browse the contents of the maps and move from one part to another according to interest and specialized field. As shown in [Figure 3](#), the interactive mapping consists of three parts:

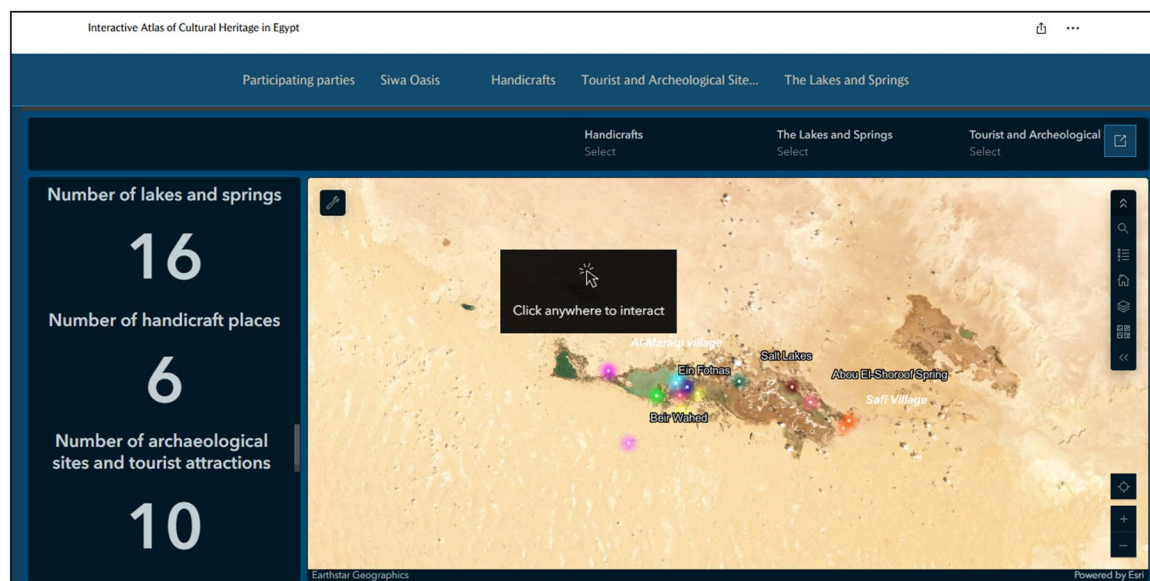


Figure 3. Components of Interactive Mapping.

Part A displays maps, photographs, and descriptive data.

Part B allows the user to select a specific site displayed in Part A.

Part C displays a map and data of all handicrafts, lakes, springs, and tourist and archaeological sites.

Part D: Sequential web pages (Story Maps) have been designed to display the entire data of Siwa Oasis CH. Story Maps is an online digital storytelling platform that displays digital datasets in a narrative format. It can be a powerful tool because of its ease of use, compatibility with other data types, and interactivity (Howland et al., 2020).

2.3.4. Evaluation of the interactive mapping and story map

Heuristic evaluation (HE) was used to evaluate Siwa's interactive mapping and story maps. HE is a usability inspection technique developed by the usability champion, Jakob Nielsen (Nielsen & Mack, 1994). HE was conducting evaluations by experts, not by users. Performing HE offers many advantages, including being cost-effective as it requires neither much time nor many users compared to traditional user testing; it does not require demanding planning, fewer people are involved, and a more straightforward analysis procedure; it is applicable in multiple phases of software, being able to be applied to planning, development, and ready-to-use products as well (Gonzalez Capdevila et al., 2025). The HE was performed independently by three evaluators (CH domain, GIS, and Academic). The evaluation criteria were selected from the updated HE developed by Gonzalez Capdevila et al. (2025) using a 1–5 scale. The evaluation criteria included:

- a. Visibility and system state
 - Does the application include a visible title page, section, or site?
 - Does the user always know where it is located?
 - Does the user always know what the system or application is doing?
- b. Connection between the system and the real world
 - Does information appear in a logical order for the user?
 - Does the system use phrases and concepts familiar to the user?
- c. Consistency and standards
 - Do the same actions always have the same results?
 - Is the information displayed consistently on every page?
 - Are the colors of the links standard? If not, are they suitable for their use?
 - Do navigation elements follow the standards? (Buttons, check box...)
- d. Recognition rather than memory, learning, and anticipation
 - Is it easy to use the system for the first time?
 - Is the information organized according to logic familiar to the end user?
- e. Color and readability
 - Do the fonts have an adequate size?
 - Do the fonts use colors with sufficient contrast with the background?
 - Do background images or patterns allow the content to be read?

3. Results

3.1. SWOT analysis and impacts on sustainability

The data collected from interviews with four official representatives in the Siwa Oasis and ten representatives of civil society associations, as well as the 109 responses to the questionnaire from craftsmen, were used to conduct a SWOT analysis, summarized in Table 1.

Strengths: The analysis highlights the preservation of heritage identity, skilled artisans, diverse archaeological sites (including Pharaonic, Islamic, and Coptic), support from civil society, and the use of locally sourced materials. These enhance sustainability by fostering economic self-reliance -e.g. date palms and olives yield 25,000 tons annually, supporting local livelihoods (Siwa Oasis | Globally Important Agricultural Heritage Systems | Food and Agriculture Organization of the United Nations, 2016). Socially, artisans maintain knowledge transfer, and organizations like Sayedat Shali promote crafts, reinforcing cultural resilience. Environmentally, the use of local materials (e.g. palm leaves, saltpeter) supports eco-friendly

Table 1. Handicrafts SWOT analysis.

First: Strengths	Second: Weaknesses
1- Preserving the heritage identity of handicrafts. 2- The presence of professionals to produce handicrafts. 3- Various Pharaonic/Islamic/Coptic archaeological areas exist in Siwa Oasis. 4- The presence of civil society organizations that sponsor heritage handicrafts. 5- Most of the raw materials used in the production of handicrafts are available locally.	1- Lack of financial support for handicrafts. 2- A sufficient marketing system for handicraft products must be improved, and marketing is limited to exhibitions only. 3- Lack of training in modern technological methods for those in charge of handicrafts. 4- Some handicraft products are not of sufficient quality due to poor finishing. 5- Lack of interest in the packaging process in a manner befitting the handmade heritage product. 6- Price differences for the same product in different locations.
Fourth: Threats: 1- Fear of the extinction of heritage handicrafts due to their non-inheritance between successive generations.	Third: Opportunities: 1- The state's interest in handicrafts and minor projects. 2- Siwa Oasis is considered an attractive tourist destination due to its presence of Pharaonic, Islamic, and Coptic archaeological sites and medical tourism. 3- The products achieve environmental sustainability as they are manufactured from environmentally friendly materials. 4- The presence of social networking sites and the possibility of exploiting them in the electronic marketing of products. 5- International bodies are ready to support the authorities responsible for heritage handicrafts financially.

practices, thereby minimizing ecological footprints. Archaeologically rich sites drive sustainable tourism, integrating cultural and natural assets without overexploitation, as seen in eco-tourism models preserving biodiversity (46 crop species, 79 wild plants) (Al-Demerdash, 2018).

Weaknesses: Financial shortages, limited marketing (restricted to exhibitions), lack of technological training, poor product quality and packaging, and pricing inconsistencies hinder sustainability. Economically, these limit market competitiveness, risking sector decline and job losses. Socially, inadequate training widens knowledge gaps, while quality issues undermine cultural authenticity. Environmentally, these practices exacerbate challenges such as soil salinization and waterlogging (affecting 85 km² from 1987 to 2003), as financial pressures drive unsustainable agricultural expansion (Siwa Oasis | Globally Important Agricultural Heritage Systems | Food and Agriculture Organization of the United Nations, 2016). Urban sprawl, replacing traditional Karsheef mud-salt bricks with concrete, further degrades cultural landscapes, causing pollution and aesthetic loss (Abdelrahman, 2013; Hamrouni & Amer, 2021).

Opportunities: Include State support for handicrafts, Siwa's tourism appeal (archaeological sites, medical tourism), eco-friendly products, social media marketing, and international funding, all of which offer growth potential. Economically, integrating handicrafts with eco-lodges or festivals, such as the National Date Palm Festival, could boost income. Socially, international support (e.g. FAO's GIAHS designation) and community programs enhance participation, countering isolation. Environmentally, sustainable materials align with Egypt's Sustainable Agricultural Development Strategy (SADS 2030), promoting water-efficient irrigation and biodiversity (Al-Demerdash, 2018). Culturally, social media can help globalize Siwa's Berber traditions, thereby enhancing their visibility and preservation.

The primary threat is the extinction of heritage due to non-inheritance, exacerbated by rapid urbanization, mass tourism, and environmental degradation (e.g. desertification, salinity from groundwater overuse) (Hamrouni & Amer, 2021). Economically, population growth fuels informal development, eroding traditional architecture. Socially, centralized governance excludes locals, fostering disengagement. Environmentally, tourism pressures strain the Siwa Protected Area's biodiversity and springs, with uncoordinated projects increasing waste (Abdelrahman, 2013; Al-Khudrawi, 2016). Culturally, these risks threaten UNESCO delisting, as noted in the 1994 tentative nomination, necessitating integrated management to prevent loss.

3.2. Descriptive documentation

During the visit, data and information were collected for heritage sites in Siwa Oasis by meeting with government departments, civil societies interested in Heritage, and those working with handicrafts in the city. The information was verified from published scientific references that have been cited in (Tables 2 and 3), and through research, heritage sites in Siwa Oasis were classified into three categories as follows:

Table 2. The main centers for handicrafts.

Site	Description
1. Aam Eissa Factory (Handicrafts from Rock Salt (Salt peter))	It is the first-of-its-kind workshop in Egypt for lanterns made from rock salt extracted from the Siwa Lakes. The salt is extracted as solid crystal bulks and goes through various forming stages. The final products are artistic handicrafts differing in shape and size, including Salt Lanterns and Lampshades, known for their physical and psychological health benefits (Mahrous, 2022).
2. Center of Handicrafts and Comprehensive Development	Silver Ornaments - Tailoring and Embroidery Clothes: The Center is the most essential development project implemented by Matrouh Governorate in 2006 in Siwa Oasis. The project aims to develop the Oasis, revive its traditional signature handicrafts, and create job opportunities for young women and girls. The Handicrafts section at the center comprises various units specializing in the production of silver jewelry and copper accessories, embroideries, knits, tailoring, and wool products, including kilims and carpets. Regularly, the center organizes educational seminars and workshops for young women and girls (AbouEllaHaredy & Ibrahim, 2020).
3. Akassia Center	Palm Leaves Products-Tailoring and Embroidery Clothes-Silver Ornaments: Embroidery-Palm Leaves Products-Silver Jewelry: The center is one of the projects implemented by (Sayedat Shali) (i.e. Women of Shali) Foundation for Handicrafts. The Foundation protects and revives the authentic Heritage of Siwa. The women affiliated with the Center work either on the Center's premises or from their own homes. Here, handmade products crafted from palm leaves, including baskets and mats, are created using a traditional weaving technique. In addition to the hand-embroidered traditional Siwa costume, made from silk and cotton threads, they also produce silver ornaments that are hand-engraved with designs characteristic of North Africa. A unit for pottery handicrafts is planned to be added soon.
4. The Production Unit (Siwa Crafts)	Carpets, Kilim, Palm Leaves Products: The Unit is famous for producing traditional art-of-the-state carpets and Kilim of Siwa, whose designs reflect the magnificent colors in the Oasis's natural landscape. The Unit offers training courses for Siwa's local women and girls and hosts a marketing and exhibition showcasing its handicrafts.
5. Safi Village	Kilim: Safi is a small village located 2 km east of Siwa. It is famous for producing kilims, which are made from 100% natural sheep's wool. Village women have woven Kilims in the same way and with the same colors throughout Siwa's history (Magdy & Zenhuom, 2023).

Table 3. The most important sites for tourists.

Site	Description
1. Fotnas Island	An island surrounded by three sides by a Salt Lake. It is one of the most famous tourist sites in Siwa. The sunset over green fields, tall palm trees, and fresh running water is a must-see sight. There is a spring on the Island (Richardson & Jacobs, 2013).
2. Gabal El-Dakroul	It is located 5 km southeast of Siwa. There are three ancient tombs carved in the mountains. The mountain area consists of three levels. The first level is a vast valley near a hill, and the second level is flat (3000 square meters) and is 10 meters above the valley. The third level is 7 meters high and can be accessed via a set of steps. The hot sand area is located behind the hill; the sand in this area is known for its curative effect on Rheumatism, especially in the summer. The scientific studies indicate that the sands, as mentioned above, contain a reasonable rate of clean radiation that helps cure diseases. An annual 3-day festival is held at Gabal El-Dakroul (in October) (Richardson & Jacobs, 2013).
3. Center of Documenting Heritage and the House of Siwa	The House of Siwa was established to preserve Siwa's Heritage, including its houses and traditional handicrafts. The museum was built to imitate the traditional Siwi house. It has the same design and structure and is made of the same materials. The museum exhibits various collections of traditional Siwa handicrafts that represent the life of the Oasis. There are unique pieces of silver jewelry, furniture, costumes (especially wedding attire), musical instruments, baskets, pottery, and agricultural tools. The local inhabitants donated the museum's collection. Siwa Public Library, also known as the Green Library, was established in harmony with Siwa's ecological system and Heritage. It was built using Kerchief stones to preserve the ancient Siwi style. It features a conference and lecture hall, a space for children, handicraft training workshops for women, and a library (Saleh, 2017).
4. Adrere Amellal	This name means (the White Mountain) in the local Amazigh dialect of Siwa. It is located 18 km from the El-Maraqui village. Adrere Amellal is distinguished by its unique geographical location; in front of the town lies Lake Gaafar, which has extremely salty water. The lake's water is recognized as a factor in the healing of certain dermatological diseases. Ain Gaafar (Gaffar Spring) is another aspect of the tourist attraction Adrere Amellal. Backing Adrere Amellal is Limestone Mountain (the White Mountain), where one of the most famous Ecological hotels worldwide was established. Adrere Amellal Hotel or Eco Lodge combines Heritage and modernity. It was built using materials from Siwa's local environment (kerchief stones, palm leaves, and wood). The Ecolodge features a combination of residential hotel rooms and a spa. There is no electricity, and the lighting depends on candles made of salt and honey (inside the lodge) and fire torches (outside the lodge). The rooms have high roofs and domes to minimize the heat and work as natural air conditioners. The furniture in the rooms is crafted from local materials, including palm leaves and wood. Some beds are made from Rock Salt (Al-Demerdash, 2018; Khudair, 2005; Rashid, 2004; Richardson & Jacobs, 2013; Rizwan, 2012).

3.2.1. Handicrafts

Handicrafts are considered an essential component of the ICH of many countries worldwide. Preserving their ICH is vital for these countries not only because it is a part of their identity, civilization, and history but also due to its massive economic impact. Throughout the ages that have led to our modern times, women in Siwa have been renowned for their exceptional and brilliant work in decorating their costumes and embroidery, utilizing various knitting techniques on dresses and veils. They use colorful silver threads in green, yellow, orange, red, and brown. Each color of the thread represents a stage of the growing process of palm Dates. Nonetheless, despite the various colors of the threads and the different embroidery shapes or figures, the designs of the costumes are unified for all the Siwa women, representing the inherited traditions. Additionally, the costumes reflect the artistic sensibilities of the Siwa people and their harmonious relationship with the surrounding natural environment (Abdullah & Arfat, 2020; Ahmed, 2017; Saleh, 2017). Table 2 presents the five main centers for handicrafts, as compiled and listed.

3.2.2. Tourist and archeological sites

Siwa Oasis is considered one of the most important tourist sites in Egypt. The Oasis is rich in diversified and unique tourism attractions. It has outstanding natural, historical, archaeological, cultural, and human aspects. Tables 3 and 4 present the most important tourist and archaeological sites.

3.2.3. Lakes and springs

Siwa is considered the Jewel of the Crown among the world's oases. It enjoys various distinguished aspects as a haven of natural and therapeutic tourism (salt lakes, springs, freshwater wells, sulfur wells, and white-hot sands).

Table 4. The most critical archaeological sites.

Site	Description
1-The Temple of Alexander (The Oracle Temple)	It is in Aghurmi village, about four kilometers from the center of Siwa. The Temple dates to the reign of King Amasis, one of the kings of the 26th dynasty. Some modifications and additions were made during the Persian, Ptolemaic, and Roman periods. The temple was dedicated to the gods Amun, Mut, and her son Khonsu. Numerous legends are associated with the founding of this temple. The temple has a front courtyard, façade, two courtyards, and three halls; the central one is the sanctuary. The sanctuary, a vestibule, side rooms, niches, a crypt, a corridor, and the remains of a staircase. (The central scene in the sanctuary represents King 'Amasis', presenting an offering to eight divinities; alternatively, the Siwa governor swaps the King. In front of the temple are the remains of the old fortress 'Shali Aghurmi', which contains houses built in the Siwa style and an old mosque distinguished by its minaret and architectural style (Ahmed Fakhry, 1973; Al-Demiri, 2016; Ibrahim et al., 2019; Wilkinson, 2000).
2- The Temple of Umm Ebeida	It is located southeast of the Temple of Oracle. It was built during the 26th dynasty (Ahmose II) and expanded during the reign of King Nectanebo II of the 30th dynasty. The temple was dedicated to the Theban triad of Amun, Mut, and Khonsu. Only one wall of the eastern wall of the sanctuary and some stone blocks from the entrance to the temple, as well as the ceiling, had remained. The wall contains a long text of 50 lines and three registers depicting different deities, a scene of the king and the ruler of Siwa kneeling in front of the god Amun (Ahmed Fakhry, 1973; Al-Demiri, 2016; Wilkinson, 2000)
3- Gebel el Mawta	Gabal Al-Mowta, 'The mountain of the Dead', is located approximately 2 km from Siwa. It is a limestone mountain that features rock tombs (approximately 600 tombs carved into the rock of the hill), dating back to the 26th dynasty, the Ptolemaic Period, and the Roman Period. Most tombs are small, consisting of one or two chambers, and some have side rooms. In addition, many burials were excavated in the rock (loculi) (Ahmed Fakhry, 1973).
4- Belad El-Rom Mountain(Roman Countries Mountain)	It is located approximately 30 km west of Siwa City, near the village of El-Maraqi. The archeological site of Belad El-Rom contains the remains of a stone temple, ancient buildings, quarries, and many rock tombs from the Greco-Roman era. Most of those tombs are mere, simple rectangular stone chambers. Some tombs contain holes or burial places (loculi) and side chambers (Abdelrahman, 2013; Al-Demiri, 2016; Hammad & Hosny, 2009)
5- Qurayshet site	It is located about 27 km east of Siwa. It includes the remains of a stone temple dating back to the end of the Ptolemaic era, a vast building, mud-brick houses, graves, and olive presses (approximately 45 presses, along with numerous mills and basins) from the Greek and Roman periods (Abdelrahman, 2013).
6- Shali Fortress (old Siwa)	The village, which means 'the city' in the Siwa language, was a 12th-century village built in the center of the Oasis. Its fortresses and houses once buzzed with inhabitants until 1926, when old Shali was abandoned. The inhabitants established their homes in the surrounding areas of the old village. The fortress consists of huddled houses made from traditional 'Kershif' materials, narrow streets, seven wells of water, and 'storage' for storing supplies. It is surrounded by a solidly built wall that initially had only one entrance, called the 'Inshal' door, meaning the city's gate. A second gate was opened on the southern side of the wall, later close to an oil press called the 'Bab that', or a new door. A third door was then opened, called 'Qaddoha', or the women's door. The village has two mosques: the ancient mosque on the northern side of the fortress wall and 'Tatnadi', also known as the Sheikh Hosniya Mosque (Al-Demiri, 2016; Aly s. Elsayed, 2016; Olaz et al., 2022; Rovero et al., 2009).

The Egyptian Nubia Reservoir is the water source that feeds the springs and freshwater wells. It is the largest reservoir in Egypt, originating from the Aswan and Nubia regions. The water crosses fast desert areas and oases until it reaches its outlet (mouth) in Siwa. Several mineral water factories (including international brands) bottle and distribute Siwa's fresh and healthy water. [Tables 5](#) and [6](#) present the most critical sites for lakes and springs.

There are four leading lakes in Siwa: (El-Zaytoon, east of Siwa, 5760 acres); (Agormi, northwest of Siwa, 960 acres); (Siwa, west of the city of Shally, 3600 acres); (El-Maraqi, west of Siwa, 700 acres). The lakes are formed as a result of irrigation and groundwater. Those lakes lack marine life because of the high level of salt concentration. There are other lakes in Siwa, including Taghageen, El-Aawsatt, Sheyata (Al-Demerdash, [2018](#); Al-Demiri, [2016](#); Al-Khudrawi, [2016](#); Hosam et al., [2017](#); H. Idris, [1996](#); Salman, [2018](#)).

3.3. Spatial documentation

[Table 7](#) (DMS Format) was directly derived from spatial documentation efforts during the field visit phase of the methodology, based on coordinates recorded in the field using Magellan GPS 300 devices. The Magellan GPS 300 is a handheld, portable satellite navigator from the late 1990s to early 2000s, known for its basic waypoint logging capabilities (e.g. storing up to 500 points of interest with 12-channel GPS reception for accuracy typically around 10–15 meters under open sky conditions). All listed sites in the table – spanning handicrafts (e.g. Aam Eissa Factory), tourist spots (e.g. Gabal El-Dakrour), archaeological features (e.g. The Temple of Alexander), lakes (e.g. Lake Siwa), and springs (e.g. Ain Cleopatra) – were geolocated on-site using this device. Coordinates were captured in Degrees-Minutes-Seconds (DMS) format, which is the innate output of the Magellan GPS 300, and manually transcribed or downloaded into a spreadsheet for initial tabulation. This step supports standard field surveying practices in archaeological and heritage documentation, where GPS units offer ground-truth data for GIS incorporation.

Table 5. The most important sites for Lakes.

Site	Description
1. Lake Siwa	The lake is located east of Siwa and is the largest (28.73 km). The Peninsula of Taghageen is on its north side, Fontas Island is on its south, and to the west of the lake, there is Gabal Gaafar and the White Mountain (El-Gabal El Abyaad) (Aly s. Elsayed, 2016).
2. El-Zaytoon Lake	It is located southeast of Aghormi Lake, a vast and deep lake (14.62 km). El-Zaytoon, Abou Shoroof, and Qorshit are some villages on the east side of the lake (Richardson & Jacobs, 2013). The areas selected for the present investigations are Siwa and Baris Oases. Siwa Oasis lies below the zero contour level elevation. It is usually referred to as the Siwa Depression. It lies about 65 km east of the Libyan border. It measures approximately 75 km in length and has a variable width, ranging from 5 to 25 km. Baris Oasis comprises the southern part of El-Kharga Oasis. It covers about 900 km ² . Generally, the climate of the Western Desert, particularly in Siwa and Baris Oases, is extremely hot and arid. Geologically, Siwa and Baris Oases are part of the Western Desert. They are occupied by deposits belonging to the Pre-Cambrian (Basement complex), Upper Cretaceous (Nubian Sandstone), Middle Miocene, and Quaternary rocks (Lake and Aeolian deposits). A grid pattern of 85-deep Vertical Electrical Sounding Stations (VES) is established in Baris Oasis to evaluate the geologic succession, lateral and vertical variations of surface and subsurface beds, delineate the cap rock, and assess the water-bearing formations and geologic structures that affect groundwater potential. The geoelectrical succession in Baris Oasis consists of 7 geoelectrical zones: the surface zone, cap rock zone, zone 'A', zone 'C', zone 'D', and basement rock zone. The geoelectrical zones ('A', 'B', 'C', and 'D') are Nubian Sandstone water-bearing zones. Hydro-geologically, the groundwater system underlies the Siwa Oasis consists of two productive aquifers. These are the Lower Cretaceous Nubian Sandstone and the Middle Miocene fractured limestone. Besides the Quaternary sand and clay, the uppermost layer is water-bearing due to waterlogging. In the Baris area, the Nubian Sandstone aquifer is the principal aquifer. It is classified into four productive zones (A, B, C, and D) and is composed of sand and sandstone separated by water-confining interbeds of clay and shale. In Siwa, the total salinity groundwater of the Nubian Sandstone aquifer, in terms of TDS, varies from 200 ppm to more than 1,500 ppm, while in Baris Oasis, the total salinity groundwater of the Nubian Sandstone aquifer is fresh and ranges from 353 to 694 mg/l and the chemical eater type is Sodium chloride (El-Deen, 2021 ; Moghazy & Kaluarachchi, 2020 ; Richardson & Jacobs, 2013).
3. Aghormi Lake	It is located northeast of Siwa and is known for its Salt Basins. Its area is 12.62 km. On the east side of the lake, there is Aghormi village, which is famous for the Temple of Revelation, Oum Ebied, the Mountain of the Dead, Cleopatra Spring, and the Gabal El-Dakrour archaeological and tourist sites (El-Deen, 2021 ; Moghazy & Kaluarachchi, 2020).
4. El-Maraqui Lake	It is located 35 km west of Siwa and has an area of 11.71 km. At its northeast end is the village of Bahiy El-Din. To the east is Maraqui, located in the western part of the Siwa Depression (Moghazy & Kaluarachchi, 2020 ; Richardson & Jacobs, 2013).
5. Salt Lakes	A landmark of Siwa, known also as the Salt Mines due to its highly concentrated salty water, this salt is of high quality according to international standards. Its unique components have therapeutic effects on inflammation-related diseases. It is used for both medical and industrial purposes (El-Deen, 2021).

Table 6. The most important sites for springs.

Site	Description
1. Ain Cleopatra	The most ancient and famous spring in Siwa is located in Aghormi village, 4km south of Siwa, and is situated near the Amun Temple. And Oum Obieda Temple. It is a round spring with a 40-meter diameter surrounded by a stone fence. The temperature of its Sulfuric water changes constantly, day and night, but remains stable in summer and winter. The lake is named after Queen Cleopatra, who is believed (but not confirmed) to have had a bath in the spring during her visit to Siwa. It is also thought that Alexander the Great visited the same spring during his journey to Siwa. It is also known as Juba (the Eye of the Sun), perhaps due to its connection to the Greek God of the Sun. The spring is also named Ein El Hammam (the Spring of Bathing) due to its connection to the traditional bathing rituals for the brides of Siwa (El-Deen, 2021).
2. Ein El-Arayes	It is located to the east of the city of Siwa. It was previously called (Thamos), i.e. (the Spring of the Bride). The second-oldest spring in Siwa is 100 years old. It is a natural water spring, 10 meters deep. The water floods through the Carbon stones with an average temperature of 27 degrees Celsius all year round. It is currently used for irrigation and is not considered a tourist site. It gained its name because it is connected to traditional wedding ceremonies. As a blessing before matrimony, the bride, accompanied by village women, visits the spring before the sun sets to wash her feet, perform ablution, and pray. The groom visits the spring at night for the same purpose. Widows visit the spring after the end of the mourning period. (H. Idris, 1996)
3. Ain El- Maamal	Located in the middle of agricultural areas in Siwa, it gained its name due to its proximity to an Olive oil factory (Maamal in Arabic) that King Fouad of Egypt established during his visit to the Oasis in 1928. The spring's water level is relatively shallow, so water is pumped and collected in a reservoir for irrigation (Ahmed Fakhry, 1973; Richardson & Jacobs, 2013).
4. Ain Temquret	Located at El-Zafreia village. It is known for its low water density, where young children learn how to swim.
5. Ain Qurshit	One of Siwa's springs with a strong water flow is connected to an 8km lake. The water is semi-salted and used for irrigation. The area was inhabited during Greco-Roman times. New springs and wells, such as the New Qurshit warm spring, were dug (El-Deen, 2021; Richardson & Jacobs, 2013).
6. Ain Safi	A freshwater Roman Spring surrounded by Palm trees and fields, it is located south of the small village (Safi) and has been inhabited for 100 years by an Arab tribe (El-Shohaibat) (El-Deen, 2021).
7. Ain Abou El-Shorooof	One of the most beautiful springs in Siwa is a warm mineral spring (Chloride, Sodium, Sulfur). Water is known for its ability to cure certain diseases. Fish are cultivated in the spring, feeding on algae to preserve the water's freshness. A concrete wall surrounds the spring, and the water is used for irrigation (Richardson & Jacobs, 2013; A. A. Saber et al., 2018)
8. Beir Wahid	Beir Wahed (meaning 'only one well') is considered Siwa's most famous safari and adventure tourism destination. It combines warm and cold water nowadays, but initially, it had only a well or spring flushing warm water. It is also known as The Well of the Great Sand Sea. It is approximately 20km from Siwa, situated in the midst of the dunes. The spring was excavated during the 60s by a Russian petroleum company. As a result of the project, a new cold-water lake was created, located 2km from the original warm-water spring (Richardson & Jacobs, 2013).
9. Ein Fotnas	A freshwater spring on Fotnas Island overlooks Salt Lake, located 6km west of Siwa (El-Deen, 2021).
10. Ein Beerizi	One of the most famous Sulfur springs in Siwa is surrounded by a concrete wall. It is known for its effect on curing dermatological diseases. The spring also provides irrigation water and cultivated fish (A. Saber et al., 2022)

Table 7. Handicraft centers, tourist sites, archaeological sites, lakes, and springs are all located in Siwa Oasis.

Activity	Name	East	North
Handicrafts	Aam Eissa Factory (Handicrafts from Rock Salt (Saltpeter)	25° 31' 02"	29° 12' 13"
	Center of Handicrafts and Comprehensive Development	25° 31' 09"	29° 13' 05"
	Akassia Center	25° 31' 24"	29° 10' 20"
	The Production Unit (Siwa Crafts)	25° 31' 10"	29° 11' 40"
	Safi Village	25° 47' 58"	29° 08' 41"
Tourist	Fotnas Island	25° 28' 51.23"	29° 11' 34.32"
	Gabal El-Dakrou	25° 33' 05"	29° 11' 33"
	Center of Documenting Heritage and the House of Siwa	25° 31' 05"	29° 12' 12"
	Adreer Amellal	25° 26' 07.82"	29° 12' 29.55"
Archeological	The Temple of Alexander	25° 32' 36"	29° 12' 18"
	The Temple of Umm Ebeida	25° 32' 41"	29° 12' 04"
	Gebel el Mawta	25° 31' 25"	29° 12' 39"
	Belad El-Rom Mountain (Roman Countries Mountain)	25° 24' 26.47"	29° 13' 41.69"
	Qurayshet site	25° 42' 34"	29° 12' 29"
Lakes	Shali Fortress (old Siwa)	25° 31' 10"	29° 12' 06"
	Lake Siwa	25° 27' 41.76"	29° 13' 2.56"
	El-Zaytoon Lake	25° 43' 43"	29° 11' 32"
	Aghormi Lake	25° 35' 51.65"	29° 12' 22.64"
	El-Maraqui Lake	25° 19' 21.17"	29° 14' 19.56"
Springs	Salt Lakes	25° 37' 16"	29° 12' 53.77"
	Ain Cleopatra	25° 33' 00"	29° 11' 48"
	Ein El-Arayes	25° 31' 38"	29° 12' 17"
	Ain El-Maamal	25° 31' 58"	29° 12' 21"
	Ain Temquret	25° 32' 01"	29° 11' 55"
	Ain Qurshit	25° 42' 42"	29° 12' 24"
	Ain Safi	25° 48' 37"	29° 09' 19"
	Ain Abou El-Shorooof	25° 44' 36"	29° 10' 59"
	Beir Wahed	25° 25' 55.87"	29° 19' 15"
	Ein Fotnas	25° 28' 45.78"	29° 11' 32.52"
	Ein Beerizi	25° 30' 44.97"	29° 12' 43.27"

3.4. Photographic documentation

The various heritage areas in Siwa Oasis were photographed during the field visit. Figures 4–7 show examples of photos taken of handicraft products, archaeological sites, lakes, and springs in Siwa Oasis.



Figure 4. Handicraft products are from the Siwa Oasis.



Figure 5. Example of tourist sites in Siwa Oasis (Fotnas Island).



Figure 6. An example of an archaeological site in Siwa Oasis is the Oracle Temple.

3.5. GIS maps

ArcGIS was used to convert the collected spatial and descriptive data into a GIS database. Then, it will be used to create thematic maps for heritage sites in Siwa Oasis. Figures 8–10 show some examples of the maps produced.



Figure 7. Examples of spring sites in Siwa Oasis (Cleopatra Spring and Ein Beerizi).

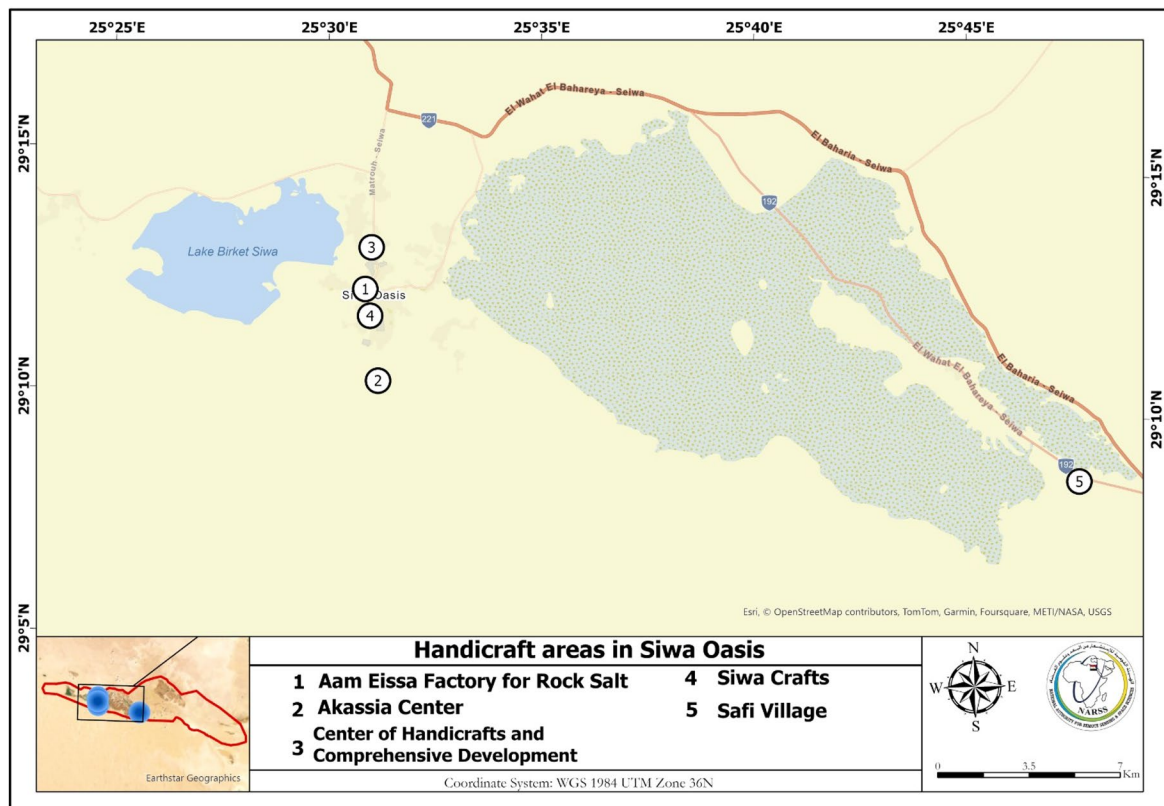


Figure 8. Handicraft centers in Siwa Oasis locations and their proximity to other cultural heritage sites play some role in preserving Siwa's intangible cultural heritage.

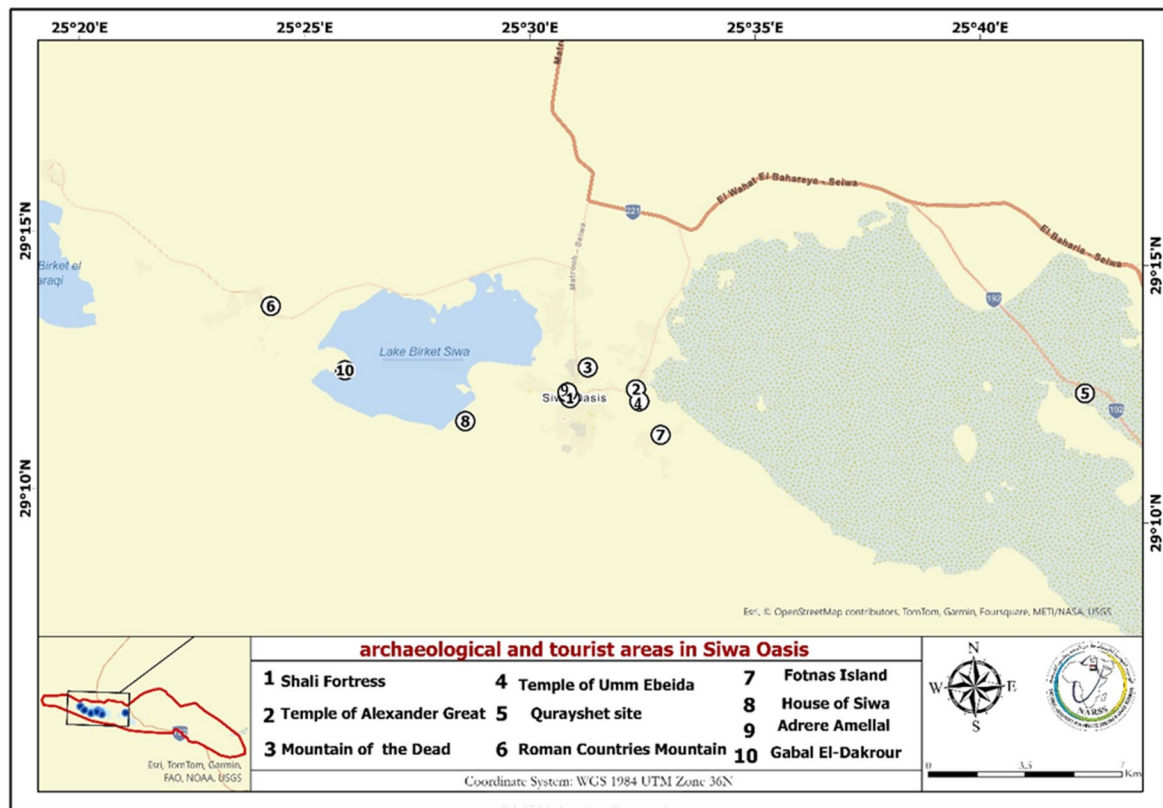


Figure 9. Archaeological and Touristic sites in Siwa Oasis.

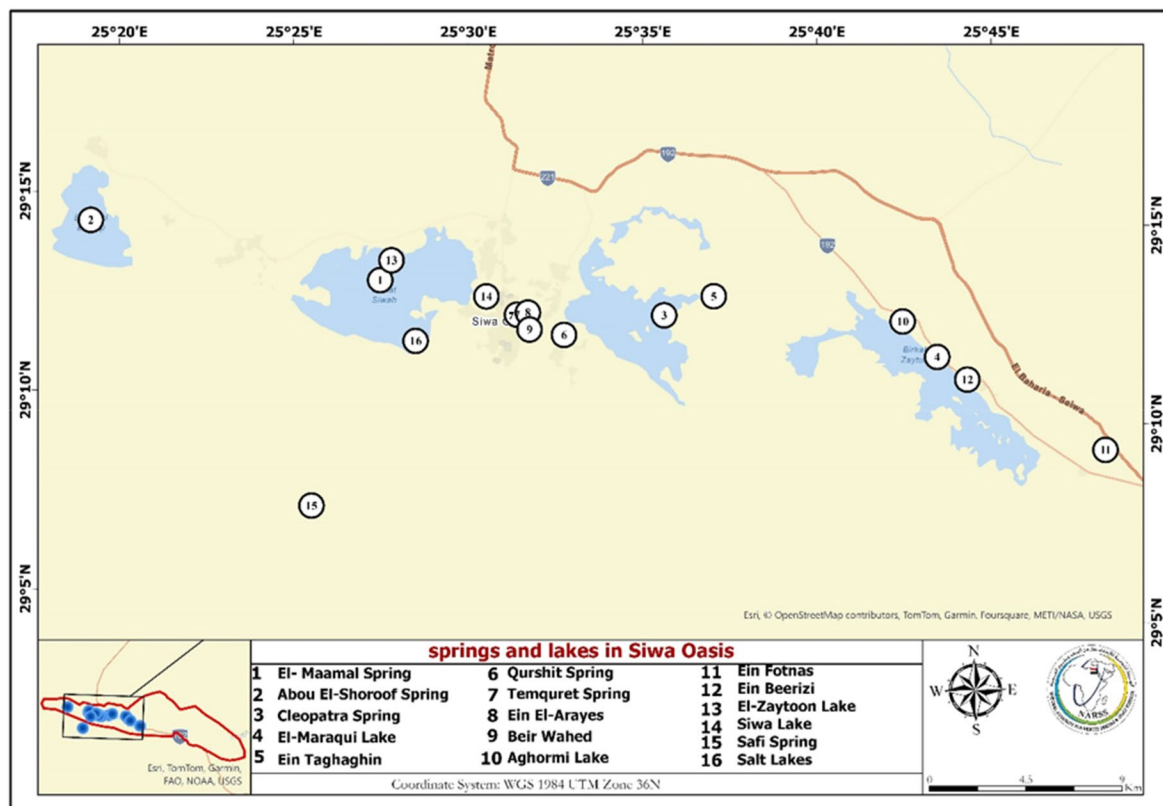


Figure 10. Springs and Lakes sites in Siwa Oasis.

3.6. Interactive maps and StoryMaps for heritage sites in Siwa Oasis

The interactive map was designed to create spatial applications that include all the documentation collected and processed for the study area (descriptive, GIS maps, and photographic). As described in Figure 3, the map offers two options. The first option allows the user to select a specific site to be displayed, as shown in Figure 11, which displays the location and data of the 'Aam Eissa Factory for Rock salt'. The second option can be chosen from the bottom of the screen. Users can display all handicrafts, lakes, springs, or tourist and archaeological sites. Figure 12 shows a map that displays all lakes and springs, while the descriptive data can be investigated individually by following the arrows. The link for the interactive map: <https://storymaps.arcgis.com/stories/8ea72cf2ac754be68be7279972662fb6>

Story Map can be displayed by choosing the 'Story Map' button at the bottom of the screen. As shown in Figure 13, the user can view the Story Map using the scrollbar or select a specific part to navigate to from the menus in the upper section.

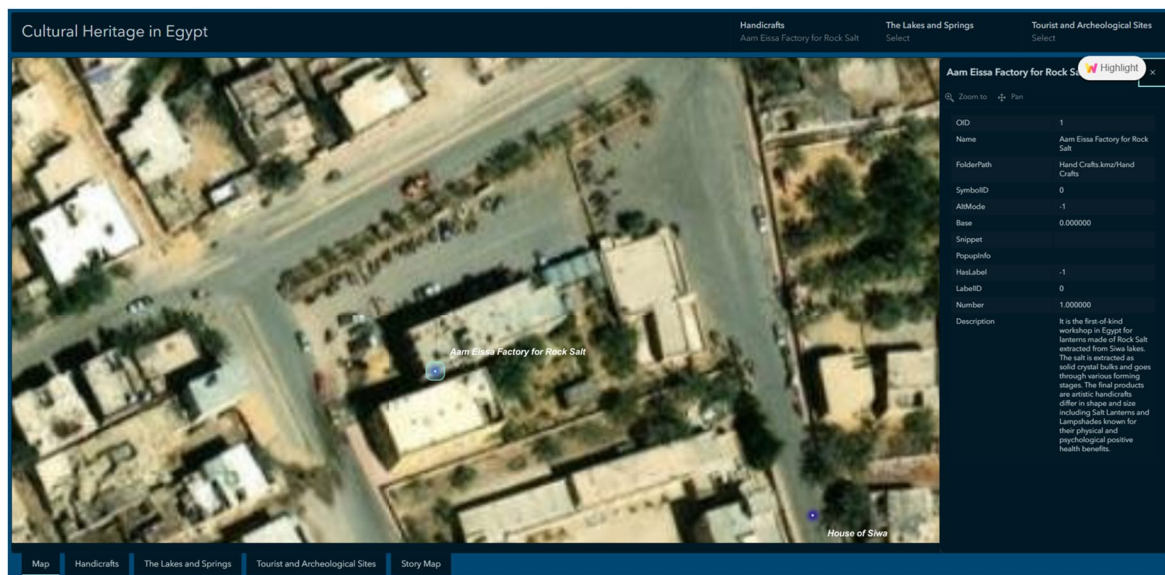


Figure 11. The interactive map displays data from specific handicraft centers.

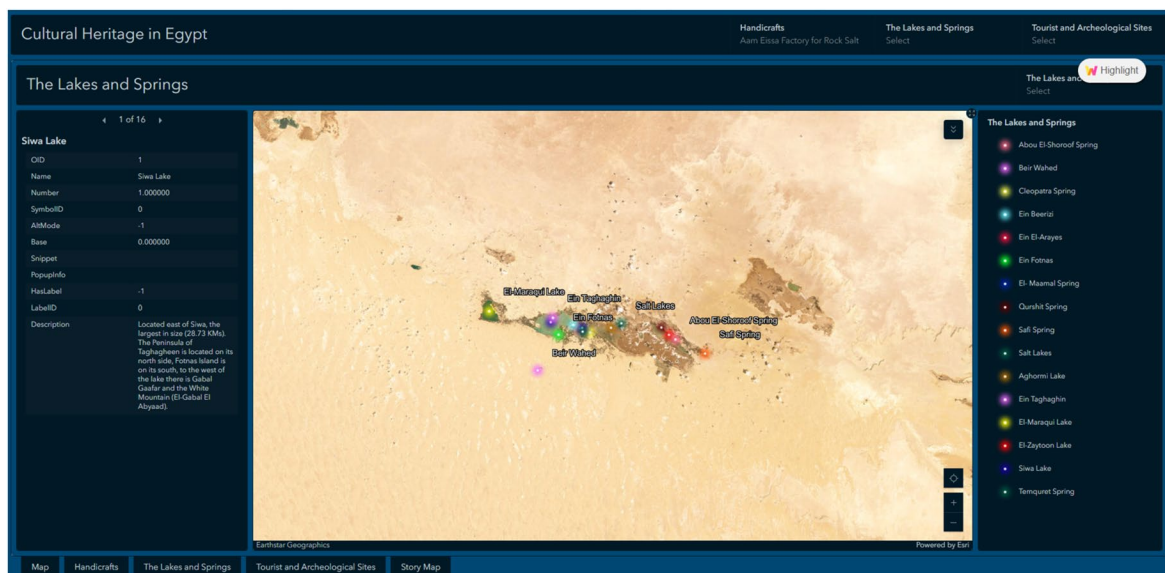


Figure 12. The interactive map displays all the lakes and springs in Siwa Oasis.

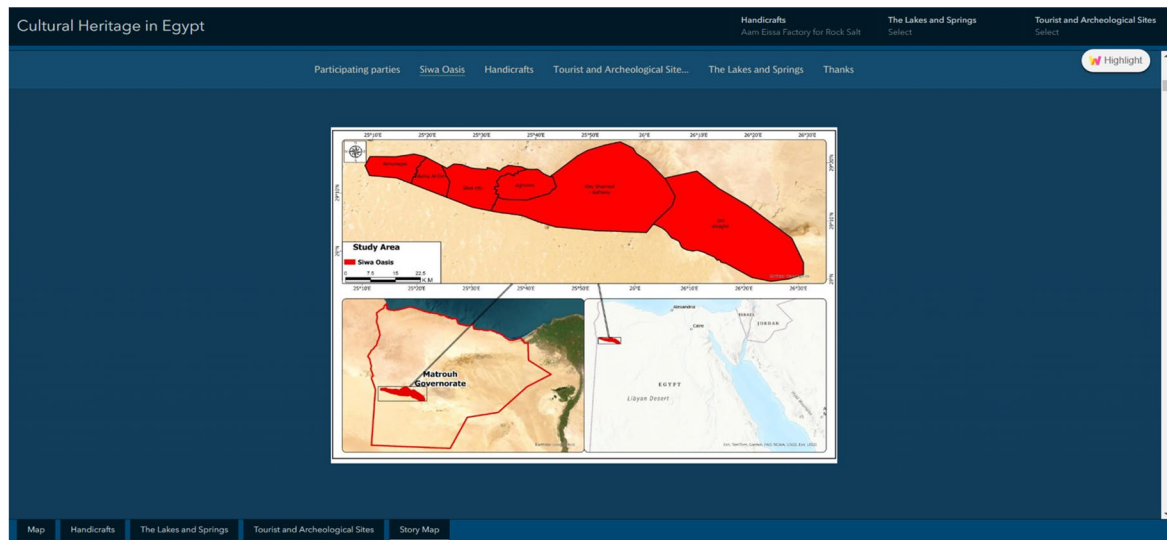


Figure 13. Part of the Story Map for CH. in Siwa Oasis.

Table 8. HE of Siwa's interactive mapping and story map results for each criterion.

Criteria	Evaluator 1	Evaluator 2	Evaluator 3
a. Visibility and system state	4	5	4
b. Connection between the system and the real world	5	3	4
c. Consistency and standards	4	4	4
d. Recognition rather than memory, learning, and anticipation	4	3	4
e. Color and readability	5	5	5

3.7. HE of interactive map and story map

As illustrated in Table 8, the heuristic evaluation indicates high usability, with an overall mean of 4.40/5 across five criteria, as assessed by three evaluators. Strengths cluster around Color & Readability (5.00/5) and Match to the Real World (4.67/5), suggesting effective cartographic design, legible symbology, and domain-appropriate terminology for Siwa's CH context. The visibility of system status, consistency, and standards both average 4/5, which is strong but leaves room for minor refinements (e.g. more precise loading feedback and tighter legend/layer nomenclature). The relatively lower score on Recognition rather than recall (3.67/5) – and the variance here (3 vs. 4) – points to discoverability gaps for core actions (e.g. filters, media, export) and to opportunities to reduce reliance on memory.

4. Discussion

4.1. Cultural heritage documentation and SWOT findings

The paper offered the results of a methodology for documenting and mapping CH in Siwa Oasis. It used digital technologies, including GIS, Interactive Maps, and Story maps, to report and display the CH sites in the study area, focusing on both tangible and intangible types. ICH is appreciated in the community, but its relevance is unknown. Still, the existence of ICH is threatened by industrialization and economic integration. In Egypt, the handicraft sector is a significant source of employment, providing over 20,000 jobs. However, this industry is vulnerable to disappearance due to several issues; one major issue is the lack of a database (Yousef et al., 2022). By focusing on producing a database and studying the status of the handicraft sector in Siwa Oasis. The status was examined through a SWOT analysis, which was conducted using data collected from interviews and a questionnaire. The main advantages were the availability of raw materials, the presence of skilled specialists capable of producing handicrafts, and the existence of ancient archaeological and tourist sites, which could aid the marketing process. The main threat was the fear of the extinction of heritage crafts due to their non-inheritance from one generation to the next. Spatial documentation of handicraft centers was created using ArcGIS, and the outputs were

visualized through an interactive map and Story Map, providing the public, experts, and decision-makers with comprehensive information about the handicraft sector.

The SWOT analysis reveals that strengths and opportunities can counter weaknesses and threats through participatory strategies. For example, eco-tourism could address financial gaps while preserving biodiversity, but requires community-driven policies to avoid overexploitation (Olaz et al., 2022; Rizwan, 2012).

The descriptive data were collected from published resources for TCH in the study area, including lakes, springs, archaeological sites, and tourist sites. In contrast, Magellan GPS 300 devices and GIS maps were used to collect spatial data during the field trips. Due to their extensive capabilities, these tools are widely utilized in CH documentation and mapping. The collected data supported the development of applications that effectively use modern information technology, such as Story Maps and interactive maps. The Story Map and interactive maps are evident references to tourists, as seen in Albania's research and many others (Mościcka & Marzec, 2010).

The study has been limited to documenting the sites of lakes, springs, and archaeological sites, as well as discovering intangible heritage sites (handicraft activities), due to the importance of preserving Siwa's activities and sustainable identity, as agreed upon in previous studies (Hamrouni & Amer, 2021).

4.2. Evaluation of the digital mapping platform and usability results

In HE of the Interactive Atlas of Cultural Heritage in Egypt StoryMap, overall usability was high (three expert reviewers; 1–5 scale; mean 4.40/5). The strongest dimensions were Color and Readability (5.00/5) and Match between System and the Real World (4.67/5), indicating clear cartography, appropriate terminology, and mapping conventions suited to Siwa's CH context. Visibility of system status, consistency, and standards scored 4/5, suggesting generally effective feedback and coherent nomenclature with minor opportunities to clarify loading states and further harmonize legend–layer labels. The comparatively lower score for Recognition rather than recall/learnability (3.67/5) indicates discoverability gaps for core actions (e.g. finding filters, opening media panels, resetting views). We addressed these by surfacing key controls near the map, adding concise tooltips and a brief 'How to use' overlay, implementing explicit map/data loading indicators, and standardizing coordinate display (WGS84), transliteration, and legend–layer naming.

4.3. Limitations and future work

Despite its contributions, the study faced several limitations. Digital platforms such as GIS and StoryMaps cannot fully capture sensory experiences (e.g. textures, sounds, smells), leading to an incomplete representation of intangible heritage (M. Z. Idris et al., 2016; Olaz et al., 2022). Technical barriers in Siwa's remote desert environment (extreme heat, dust storms, lack of internet/power, shifting dunes) degraded GPS data quality and device performance. The Magellan GPS 300 provided only 10–15 m accuracy, and environmental changes (salinization, urban sprawl) can quickly obsolete coordinates (Hamrouni & Amer, 2021; Kolivand et al., 2018). The scope was restricted to handicrafts, archaeological sites, tourist attractions, lakes, and springs; other ICH elements (oral traditions, Berber language, festivals, healing practices) were excluded. Usability was evaluated only by three experts via heuristic evaluation, not by end-users. The platform lacks real-time community updating, multilingual support for non-literate locals, and climate-risk or tourism-impact layers.

CH is at risk from the impacts of climate change (Van Balen, 2017). Updating the interactive map with an increasing database of identifying risk mapping for visitors and a climate map throughout the year is recommended.

This research paves the way for future studies to utilize technology to discover previously unseen historical places and document any updates that delve into specific aspects of Siwa's Heritage or any other location. Areas such as the impact of tourism on local practices, the role of younger generations in heritage preservation, and the qualitative assessment of community engagement in cultural activities could enrich our understanding of these topics. Additionally, further refinement of the interactive map could include features that facilitate community input, enabling continuous updates and inclusivity.

Furthermore, it is essential to identify any threat that may affect tourism or the development of Oasis. Future work should incorporate high-precision GNSS, offline/mobile community-editing tools, augmented-reality sensory layers, and participatory crowdsourcing to create a truly living, inclusive digital heritage ecosystem for Siwa.

5. Conclusions

CH documentation is essential in all societies to preserve their identity. Egypt's CH is unique and diverse but lacks documentation in many places. Siwa Oasis is one of the places with various CH but lacks complete documentation. This study proposed a methodology for spatial, descriptive, and photographic documentation of ICH represented in handicrafts and TCH represented in archaeology, lakes, and springs. The collected data is organized in a GIS database and presented through an interactive map and Story Maps.

The study conducted a SWOT analysis for the handicrafts industry. Based on the SWOT analysis, this study offers several recommendations for the handicraft industry, including addressing exaggerated pricing, establishing a website to showcase heritage handicraft products, expanding sales outlets nationwide, utilizing the Ministry of Antiquities' sales outlets in archaeological areas, and leveraging social media for international marketing. It also recommends qualifying handicraft makers to create high-quality products with modern touches, leveraging academic support from specialized art colleges in Egypt, and establishing a unit in the governorate's office to monitor, evaluate, and price traditional handicraft products. These measures aim to strengthen marketing opportunities and promote the Heritage of Egypt's handicraft industry.

The study reveals that CH documentation is essential to sustain the current location of Siwa's ICH. Additionally, the availability of this database will provide a clear vision for developing the Oasis.

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Authors contributions

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Data availability statement

The data that support the findings of this study are openly available at <https://storymaps.arcgis.com/stories/8ea72cf2ac754be68be7279972662fb6>

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